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The Resources Agency
Department of Water Resources

BULLETIN No. 183-1

SAN BERNARDINO COUNTY FLOOD HAZARD INVESTIGATION: UPPER LYTLE CREEK

March 1973

NORMAN B. LIVERMORE, JR.
Secretary for Resources
The Resources Agency

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Governor
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Aerial View of Study Area

The study area consists of the canyon
area of the upper Lytle Creek, extending
approximately three miles upstream from
a point just downstream of the confluence of the
North, Middle, and South Forks

Photo from San Bernardino County Flood Control District


NORTH FORK
MIDDLE FORK
SOUTH FORK

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FOREWORD

With the increasing urbanization of Southern California, residents have gone further afield in search of suitable building sites. As a consequence, hillsides have been cleared, grasslands have been paved, and the floodplains of rivers and creeks have been populated. The periodic floods that may once have done little permanent damage have become possible disasters.

Recognizing the hazard posed by construction in the floodplains of uncontrolled rivers and creeks, the Department of Water Resources has undertaken a series of cooperative studies with local agencies to evaluate the extent of this potential danger. Authorization for the Department to conduct such investigations is contained in Section 226 (b) of the California Water Code.

The study reported in this bulletin is one of a series of cooperative investigations. It was requested by the San Bernardino County Flood Control District and was financed with matching funds by the Department and the County.

Special appreciation for assistance and cooperation in this study is due the U. S. Geological Survey.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
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State of California
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ABSTRACT

The area covered is the canyon bottom of the upper Lytle Creek extending approximately 3 miles upstream from a point just downstream of the confluence of the North, Middle, and South Forks. The report consists of maps delineating the areas of potential inundation from floods of 50- and 100-year recurrence intervals, profiles of the streambed and water surface for floods of both magnitudes, and descriptions of how these were determined.

CHAPTER I. INTRODUCTION

Accelerated growth in San Bernardino County during the past few decades has resulted in extensive development of the alluvial fan of a number of the streams in the County. Although flood control works have been constructed to protect many areas, developments on private lands within the mountain canyon areas have increased. As a result, these latter developments have been subjected to intensive damage by recurrent floods.

Recognizing the need to prevent loss of life and damage to property, the Department of Water Resources, at the request of the San Bernardino County Flood Control District, undertook this study of the flood hazard along upper Lytle Creek. The findings will provide local agencies with a basis for developing regulations and flood control plans to safeguard lives and property within this canyon area.

Objective and Scope of the Investigation

The objective of the investigation is to delineate potential areas of inundation from floods of 50-year and 100-year frequency so that local agencies can take appropriate action for flood control and floodplain management.

The investigation that was carried out to develop this information was a reconnaissance-level study. It was conducted over a two-year period.

A study of the characteristics of the entire watershed was essential to the investigation because they help determine the size of the resulting flood. However, the study area itself was considered to be only the approximately three miles of canyon bottom just above and just below the confluence of the North, Middle, and South Forks of Lytle Creek.

Data used in the investigation came from the Department of Water Resources, the San Bernardino County Flood Control District, the National Weather Service, the U. S. Army Corps of Engineers, and the U. S. Geological Survey.

Area of Investigation

The study area lies on the eastern portion of the San Gabriel Mountains within the San Bernardino National Forest in San Bernardino County, about 60 miles east of the City of Los Angeles and 14 miles northwest of the City of San Bernardino. (See Figure 1.) It consists of the canyon area of the upper Lytle Creek, extending approximately 3 miles upstream from a point just downstream of the confluence of the North, Middle, and South Forks.

The canyon bottom along this reach ranges up to about 1,000 feet in width. Elevation of the streambed descends from about 3,510 feet to 2,840 feet above USC and GS mean sea level datum.

Rainfall average was about 34 inches per year for the period 1940 to 1970 at the Lytle Creek Ranger Station near the study area. Most of the rain falls in the winter.

Lytle Creek, in its upper reaches, has a year-round flow that furnishes the domestic supply for residents of the canyon. Below the study area, water is diverted from the stream for irrigation and domestic use and for power generation by Southern California Edison Company.

The communities of Lytle Creek and Scotland lie within the study area.

Both are unincorporated settlements of less than 500 residents each. Many of the residents commute to work in San Bernardino and other nearby communities, but some are retired. The canyon is served by a paved road that parallels the streambed.

In addition, a number of houses and mobile homes scattered throughout the canyon are used as vacation homes. Glenn Ranch, which is in the study area, is used by church groups and other organizations for recreation. Also included in the study area are the U. S. Forest Service's Applewhite Campground and Sportsman's Park, which is a privately owned picnic ground.

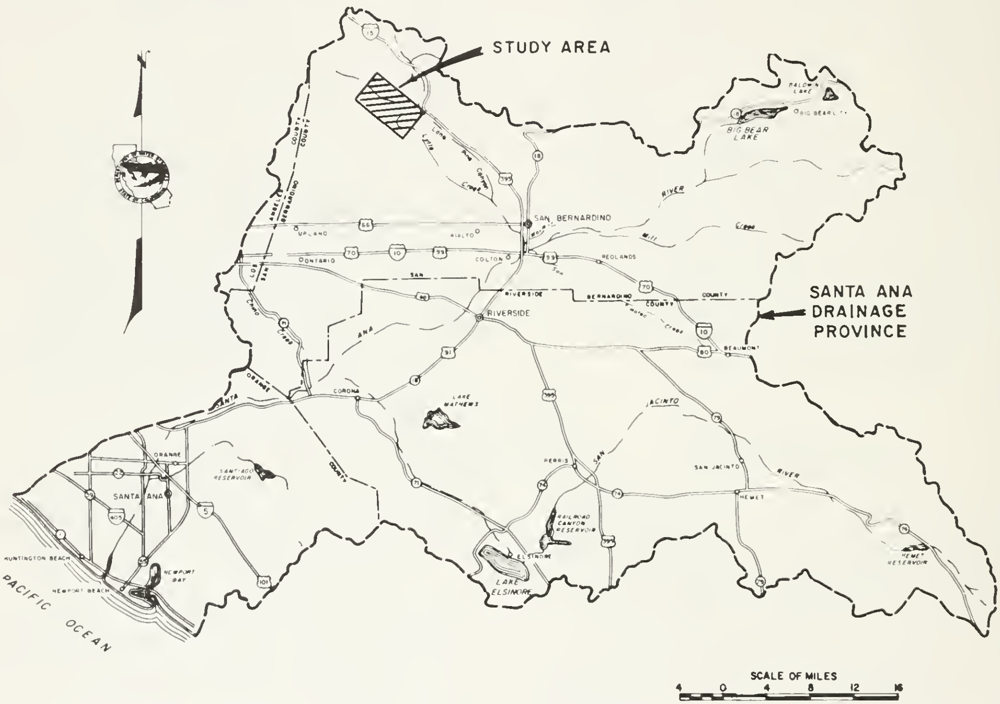

Figure I - VICINITY MAP

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CHAPTER II. PHYSICAL CONDITIONS

To help gage the size of the floods that may be expected on the floodplain, one must look at (1) the characteristics of the storms, (2) the characteristics of the drainage basin contributing runoff, and (3) the characteristics of the streambed and floodplain.

Climate and Storm Characteristics

Although the Upper Lytle Creek Basin is located in a mountainous terrain that is part of a semiarid region, it is subject to extremes in temperature and heavy rain and snowfall. In general, the highest rainfall comes from subtropical storms moving in from the Pacific Ocean in the months of November through March.

An isohyetal map (Figure 2) shows the amount of rainfall for the period January 18 to 26, 1969. This storm resulted in the highest runoff of record, as may be seen in Table 1. The high runoff was the result of a saturated watershed as well as heavy precipitation. The resulting runoff is calculated to have a recurrence interval of once in 52 years, based on stream gaging data from 1920 to 1970.

Private developments near the confluence of the North, Middle, and South Forks and those utilities and roads that serve these developments have sustained most of the damage measurable in dollars. Recent floods have also taken their toll in human life. (The photographs show some of the damage caused by the January 1969 flood.)

Watershed Characteristics

The Upper Lytle Creek Basin starts near Mt. San Antonio in the San Gabriel Mountains at an elevation of about 10,000 feet above sea level and trends in a southeasterly direction for about 14-1/2 miles to the gaging station southeast of Turk Point at elevation

TABLE 1

MAJOR FLOODS AT
GAGING STATION "LYTLE CREEK NEAR FONTANA"

Date		Quantity of flow, in cfs
January	1969	35,900
March	1938	25,200
	1922	(16,000)*
	1940	(11,000)*
December	1965	9,120
December	1966	7,200

*Correlated between Stations at "Cajon Creek near Keenbrook" and "Lytle Creek near Fontana".

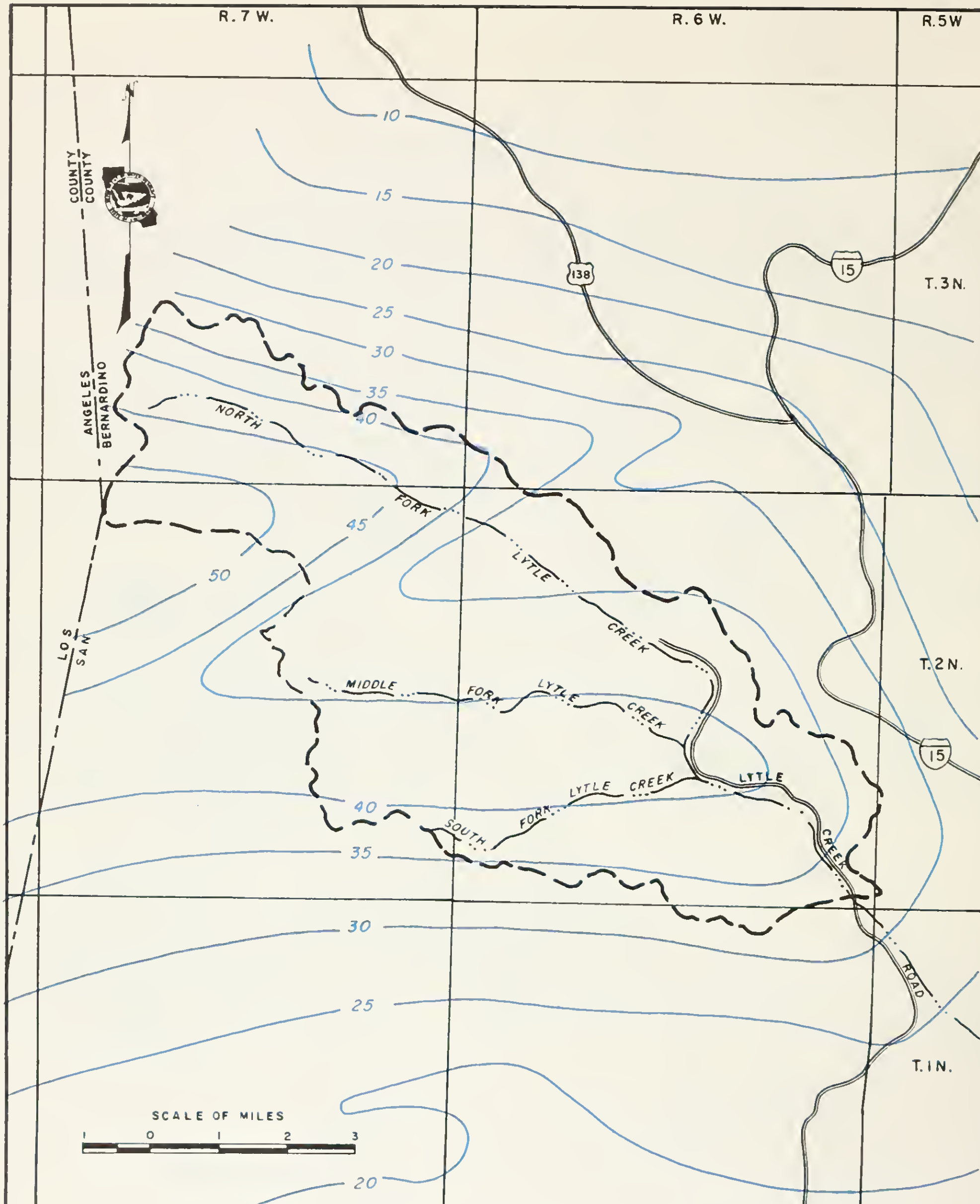

Figure 2 - UPPER LYTLE CREEK WATERSHED
TOTAL STORM PRECIPITATION, JAN. 18-26, 1969
IN INCHES

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Scenes from Flood of January 1969

Above: Damaged cabin on North Fork

Upper right: Lytle Creek Road

Lower right: Near Scotland store

Below: Near confluence of North and Middle Forks

Photo above from San Bernardino County Flood Control District; All others: The Sun Company photos

2,377 feet. The basin so defined is made up of mountains, canyons, and foothills.

The mountains and foothills are covered with a thin mantle of residual soil.

The mountain slopes in much of the basin have been denuded by a series of recent fires. This has brought about a decrease in the infiltration rate of rainfall and an increase in the runoff potential from the steep slopes. The additional runoff, together with high stream velocities and heavy loads of debris, would tend to increase the amount of scouring action.

Parts of upper Lytle Creek have a small year-round flow fed by seasonal precipitation that has been stored temporarily in fractures and joints. Large surface runoff occurs only after storms, and evidence may be found of widespread destructive flooding in the basin.

Vegetation along the streambeds of Lytle Creek and its many tributaries is sparse, consisting mainly of sagebrush and other flora characteristic of similar semiarid regions in California. Scattered stands of sycamore and cottonwood grow along the streambeds.

Vegetative areas alongside the stream are normally key habitat areas for wildlife resources. The stream itself provides an environment that supports aquatic resources including a trout fishery.

Characteristics of the Streambed

The upstream part of Lytle Creek follows the San Jacinto fault. The streambed is covered by boulders of various sizes and deposits of gravel, sand, and clay. The alluvium is thin.

The streambed is steep and water velocities sometimes exceed 30 feet per second. Past floods also indicate that the streambed is erodible and unstable.

During floodflows, the stream carries large quantities of debris, as may be seen in the photographs. This debris could cause obstruction in the channel and thus increase flood heights.

These are unpredictable factors which were considered but not reflected in the calculations.

CHAPTER III. FLOOD ANALYSES

By analyzing the records of floods in the area, the recurrence intervals of the various floods can be determined, and the peak discharges for floods of 50- and 100-year recurrence intervals can be estimated. With this information the areas of potential inundation from these floods can be delineated.

A flood of 100-year recurrence is defined as a peak flow that can be expected to be equaled or exceeded on the average of once every 100 years. However, this does not imply the recurrence of such a flood at uniform 100-year intervals, but rather the probability that a 100-year flood occurring or being exceeded within any one-year-period is 1 percent.

A 50-year flood can similarly be defined as a peak flow that can be expected to be equaled or exceeded on the average of once every 50 years.

Determination of Recurrence Intervals

For determining recurrence intervals, records were used of annual peak floods from the gaging station "Lytle Creek near Fontana", which is approximately 3.4 miles downstream of the study area. This station, which was installed in 1920, monitors runoff from a watershed of 46.9 square miles. The study area lies within this watershed, as may be seen on Figure 5 on page 12.

Where records were not available for any particular year, the values were obtained by a simple graphical correlation between the two gaging stations of "Lytle Creek near Fontana" and "Cajon Creek near Keenbrook". This second station is approximately 2 miles east of the study area.

To determine the recurrence interval for each flood, the equation used is:

$$\text{Recurrence interval} = \frac{n+1}{m}$$

Where $\underline{n}$ is the number of years of record (51) and $\underline{m}$ is the order of magnitude of the annual peak discharge, with the highest being 1 and the lowest being 51.

Table 2 shows the peak discharges, the order of size of each, and the computed recurrence intervals. (Note that recurrence intervals were not obtained for the correlated values.)

The peak discharges were then plotted against recurrence intervals and a smooth curve drawn, as shown on Figure 3. Note that an exception to the plotting criteria was made in utilizing data on the 1969 flood. By use of the recurrence interval formula, the 1969 flood would have a plotting position of 52 years. However, a search of 100 years of newspaper files showed no record of flood greater than this.

Therefore, for the 1969 flood, the peak discharge was plotted at recurrence intervals of both 52 and 100 years.

The smooth curve of best fit was then drawn between the two plotted first order points.

Estimation of Peak Flood Discharges

The peak flood discharges employed for delineating areas of potential inundation and the corresponding water surface profiles were determined from the "modified rational formula". This is one of the methods the San Bernardino County Flood Control District uses to compute its peak flows.

TABLE 2

FLOOD DATA FOR GAGING STATION "LYTLE CREEK NEAR FONTANA"

Water* year	Peak** discharge, in cfs	Order (m)	Recurrence interval, in years	Water* year	Peak** discharge in cfs	Order (m)	Recurrence interval, in years
1920	291	32	1.63	1946	(800)	21	
1921	160	36	1.44	1947	1,000	16	3.25
1922	(16,000)	3		1948	140	37	1.41
1923	(840)	19		1949	200	35	1.49
1924	(50)	50		1950	207	34	1.53
1925	(62)	49					
1926	500	29	1.79	1951	65	48	1.08
1927	5,300	9	5.78	1952	1,500	13	4.00
1928	(90)	44		1953	98	42	1.24
1929	(73)	47		1954	780	22	2.36
1930	(730)	25		1955	114	39	1.33
1931	417	30	1.73	1956	964	17	3.06
1932	865	18	2.89	1957	575	27	1.93
1933	100	41	1.27	1958	1,190	15	3.47
1934	560	28	1.86	1959	832	20	2.60
1935	1,500	12	4.33	1960	96	43	1.21
1936	730	26	2.00	1961	102	40	1.30
1937	1,250	14	3.71	1962	760	23	2.26
1938	25,200	2	26.0	1963	122	38	1.37
1939	(1,600)	11		1964	277	33	1.58
1940	(5,500)	8		1965	80	45	1.16
1941	(6,100)	7		1966	9,120	5	10.4
1942	(30)	51		1967	7,200	6	8.67
1943	4,800	10	5.20	1968	336	31	1.68
1944	(11,000)	4		1969	35,900	1	52 & 100
1945	(735)	24		1970	76	46	1.13

*Water year ends on September 30 of year shown.

**Discharge values shown in parentheses are synthetic value derived by correlation between gaging stations "Lytle Creek near Fontana" and "Cajon Creek near Keenbrook".

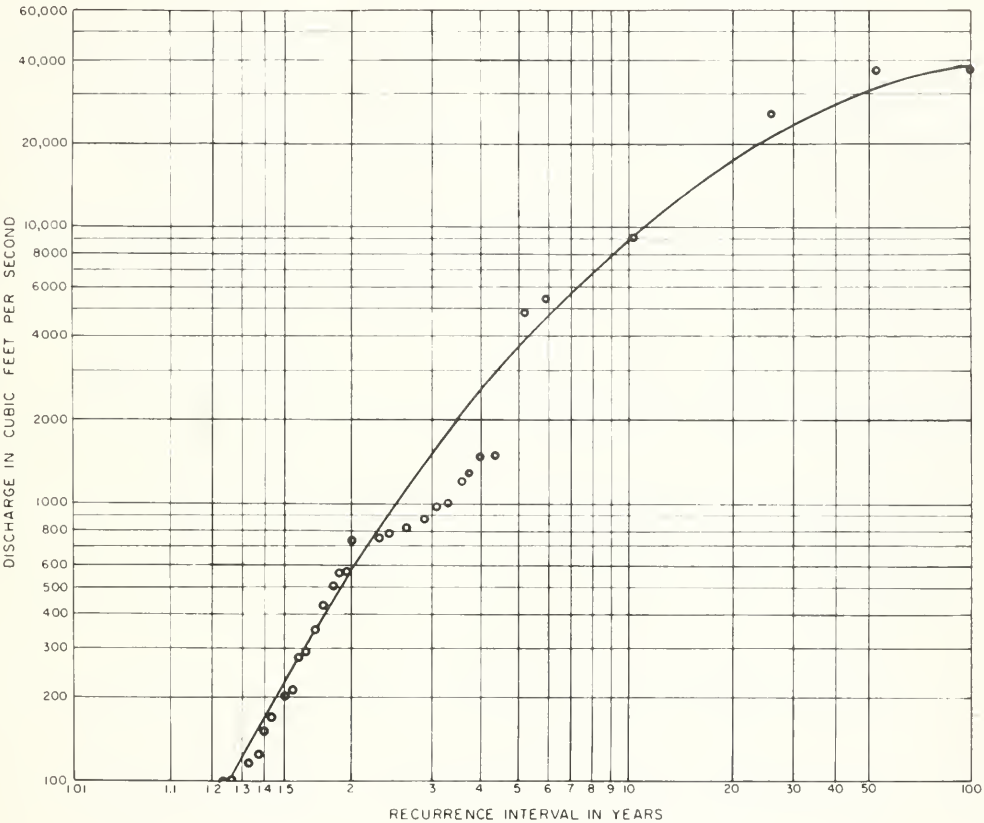


Figure 3 -DISCHARGE-FREQUENCY CURVE
AT "LYTLE CREEK NEAR FONTANA" GAGING STATION

The formula used is:

$$Q = c\ i\ a$$

where c = runoff coefficient
i = rainfall intensity, inches/hour
a = area in acres

The value of i was determined from various maps and curves furnished by the San Bernardino County Flood Control District. The initial step called for obtaining a 10-year frequency 1-hour rainfall intensity value from the isopluvial map for the study area. This value was then adjusted to the desired frequency by use of Figure 4. By knowing the time of concentration and the 60-minute rainfall, the value of i was then obtained from Figure 6.

Next, the peak discharges were computed, with the above formula, for the various watersheds by assigning the runoff coefficients.

The runoff coefficients ranged from 0.37 to 0.68 for the 50-year frequency computation and from 0.49 to 0.70 for the 100-year frequency computation.

At the confluence of the North Fork with the Middle and South Forks, the discharges were adjusted according to the ratio of the intensities of the rainfall to account for the different times of concentration.

Table 3 is a summary of the estimated peak discharges on each of the forks of Lytle Creek at points just above and below their confluence.

These runoff coefficients, which are variables, were refined so that the total peak discharges matched reasonably well with the discharge-frequency curve given on Figure 3, which had been derived for the gaging station downstream of the study area.

Determination of Areas of Potential Inundation

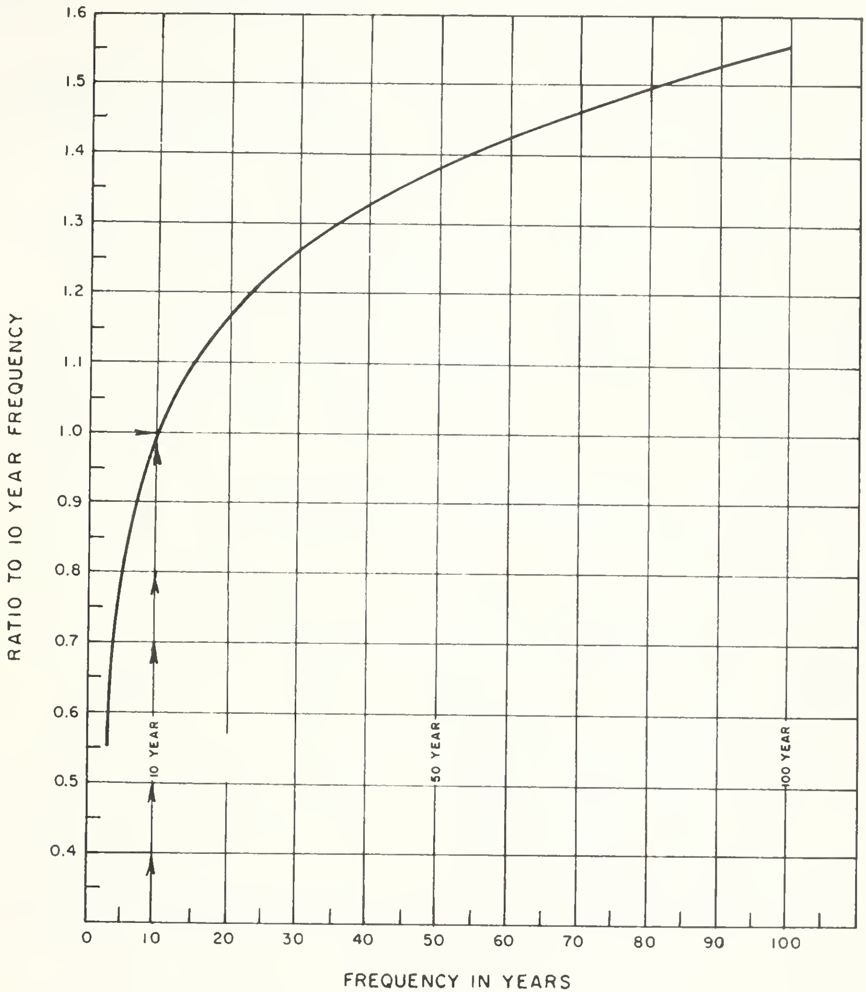
To determine the areas of potential inundation, the water surface elevations along Lytle Creek and its tributaries were computed for 50- and 100-year floods.

Using maps, furnished by the County that had been drawn to a horizontal

TABLE 3

PEAK DISCHARGES FOR NORTH, MIDDLE, AND SOUTH FORKS OF LYTLE CREEK

Location	Drainage area in square miles	Peak discharge in cfs	
		50-year	100-year
North Fork Lytle Creek above confluence with Middle Fork	23.1	14,000	18,700
Middle Fork Lytle Creek above confluence with North Fork	11.6	12,100	14,100
North Fork Lytle Creek below confluence with Middle Fork	34.7	22,900	29,100
South Fork Lytle Creek above confluence with North Fork	5.5	7,600	8,800
North Fork Lytle Creek below confluence with South Fork	40.2	27,300	34,300



NOTE: PLOTTED FROM S.B.C.F.C.D. STANDARD
M.P. 1076, DATED 11-27-57

Figure 4 — INTENSITY-FREQUENCY RELATION CURVE

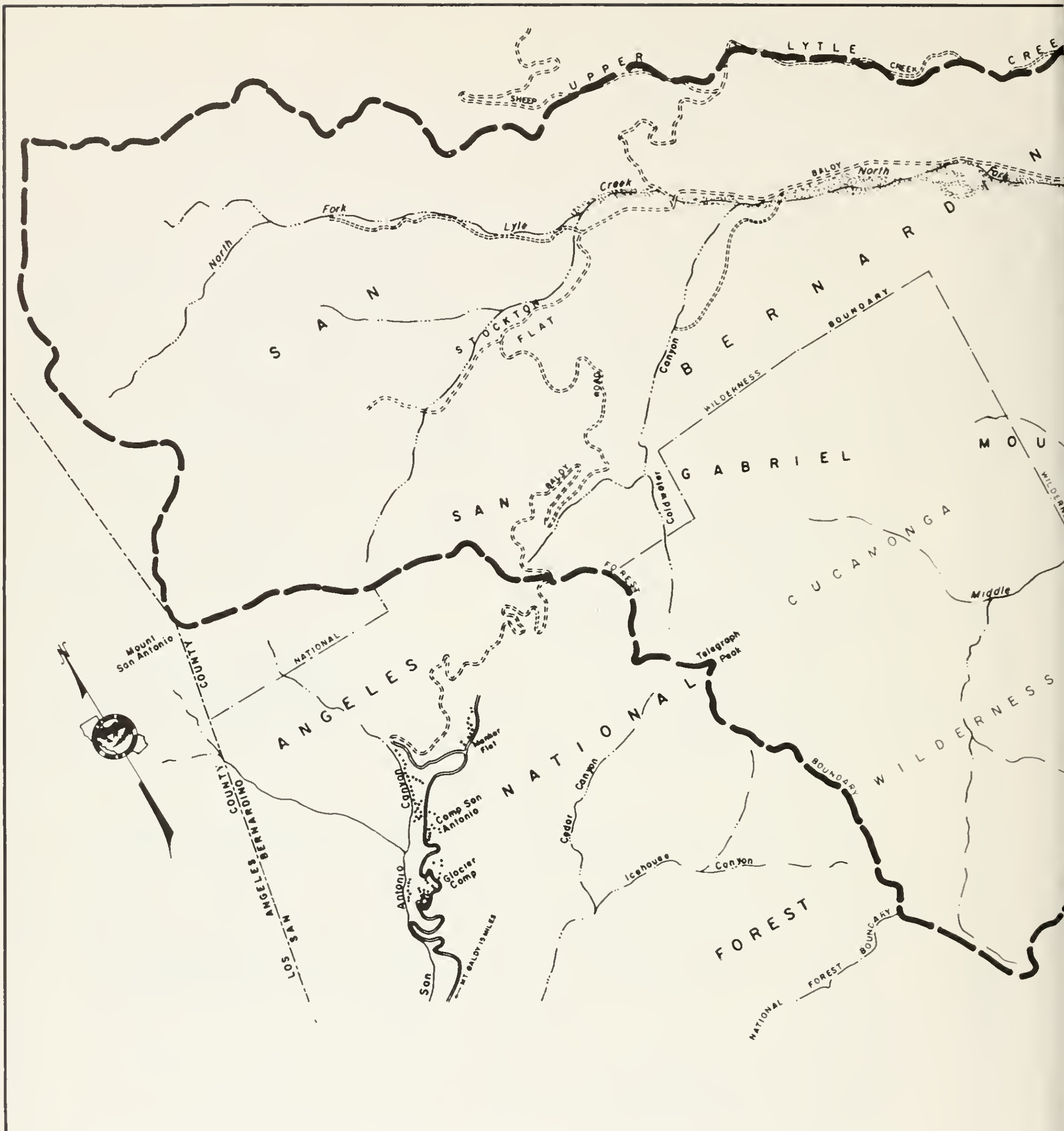


Figure 5 – UPPER LYTLE CREEK WA

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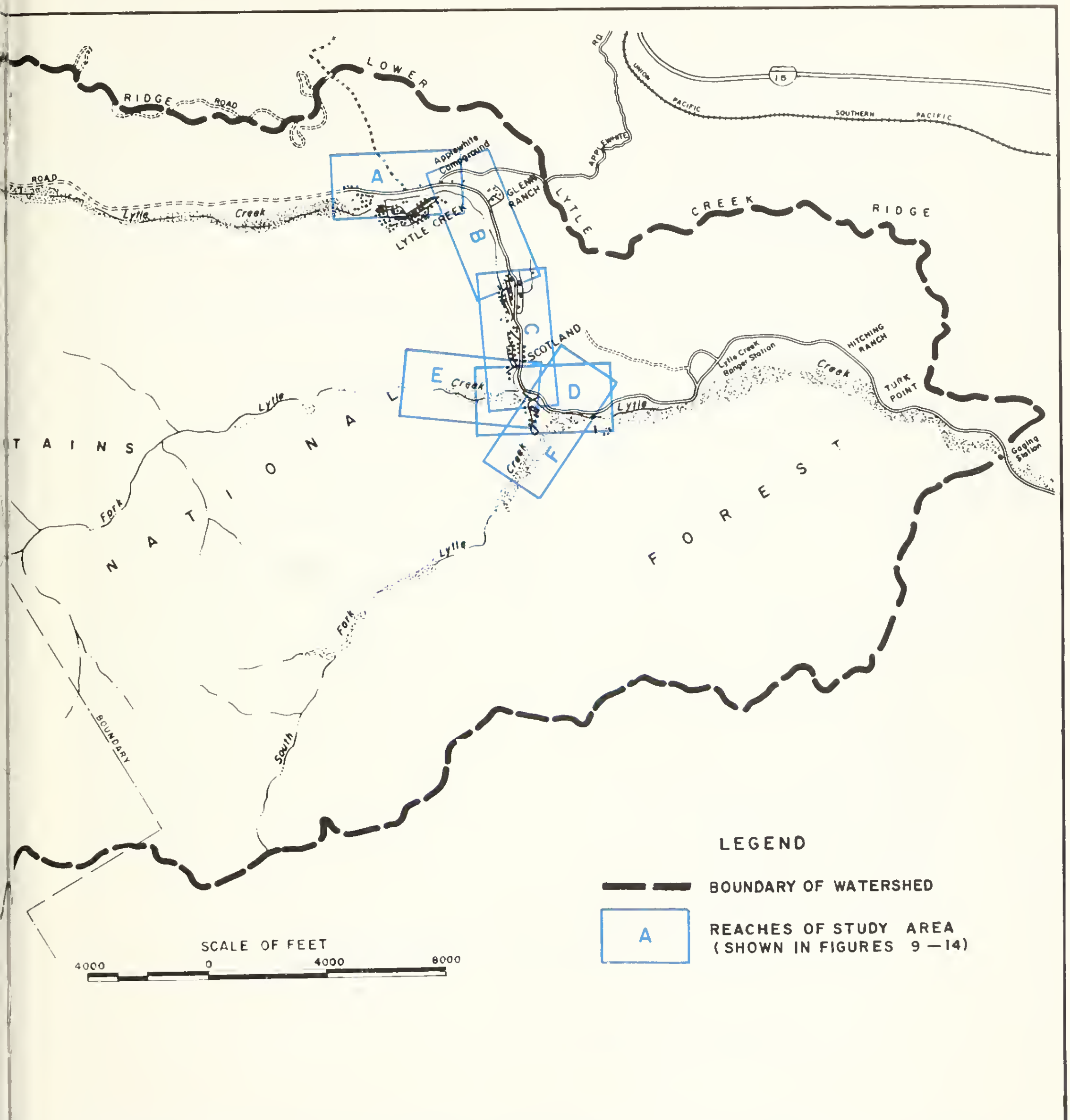
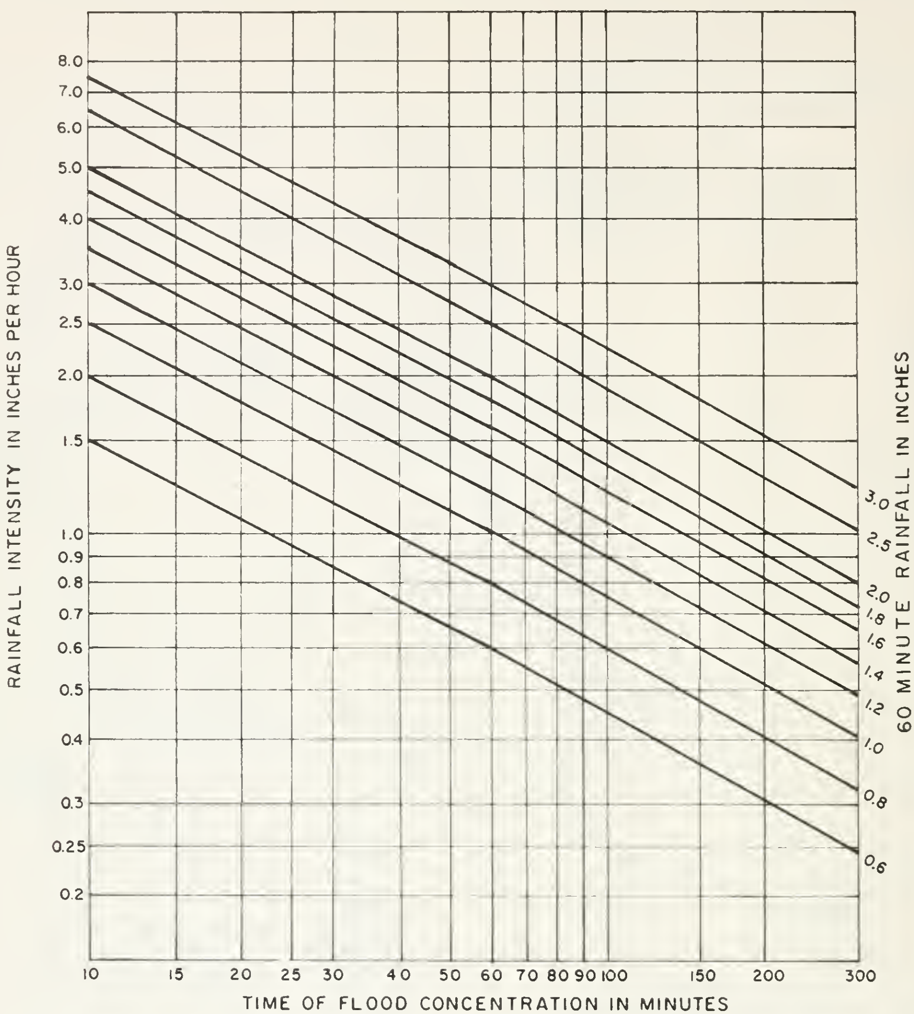


RSHED AND STUDY AREA



NOTE: PLOTTED FROM S.B.C.F.C.D STANDARD
M.P. 1075 DATED 1-26-60

Figure 6 — INTENSITY-DURATION CURVES

scale of 1 inch equals 200 feet and showing 4-foot contour intervals, cross sections were taken at maximum intervals of 200 feet. So that the calculations could be handled on a computer, these cross sections were translated into machine input.

To compute the water surface elevations, Bernoulli's theorem was used for calculating total energy at each cross section and Manning's formula for calculating the friction loss between cross sections.

For computation, each section was then subdivided according to its main channel and overflow areas, and the appropriate roughness coefficient was assigned to the subdivisions to determine friction loss. Expansion and contraction losses were also considered to determine head loss between sections. The computation of water surface elevations was started at a point approximately 200 feet upstream of the study area. Because of the absence of a control point, or known water surface elevation, the initial depth for the first cross section was assumed to be at critical depth. Although this assumed depth may be slightly more than the actual depth, it should be the same within a short distance downstream because the streambed has such a steep gradient. Figures 7 and 8 show the profiles of the streambed and the computed water surface elevations for the 50- and 100-year floods.

The computation indicates that, for all practical purposes, the flow is supercritical throughout the reach. However, at points the water surface elevation exceeds the critical water surface elevation, indicating a possibility of a hydraulic jump. Further investigation showed that these jumps were of minor undulating nature. Computations were then continued downstream at these locations by assuming critical depth.

Figures 9 - 14 show that extensive portions of the community of Scotland would be inundated by both the 50-year and 100-year floods, whereas most of the homes in and near the community of Lytle Creek are above the area that would be flooded.

The maps also show that the main road through the canyon, which parallels the creek, would be under water in places, as also would be many of the connecting roads to individual homes.

To ensure the reasonableness of the areas to be inundated under these floods, a comparison was made with the areas inundated under the 1969 flood shown on maps provided by the County. They were found to be similar.

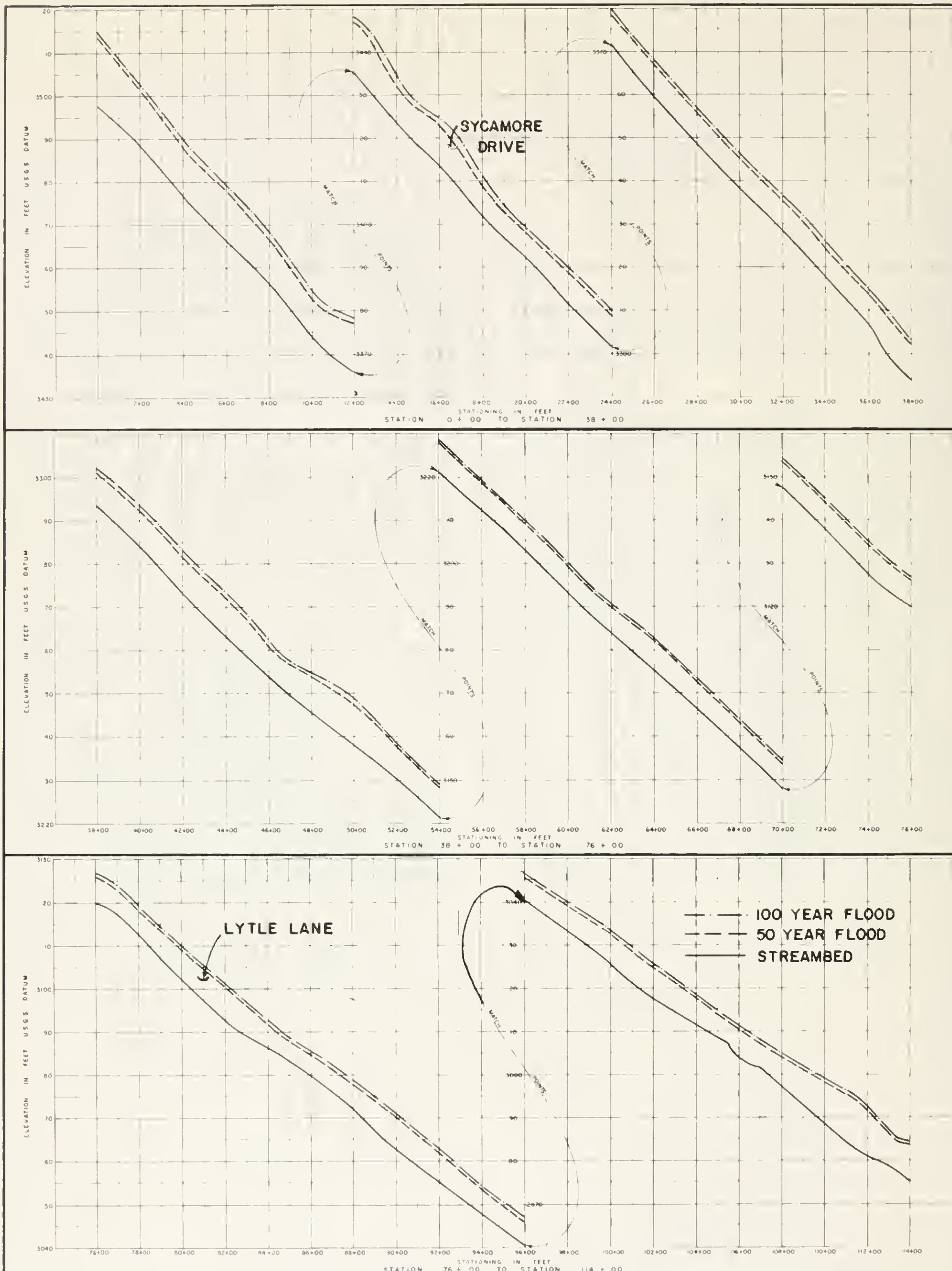


Figure 7 – FLOOD PROFILES: NORTH FORK LYTLE CREEK

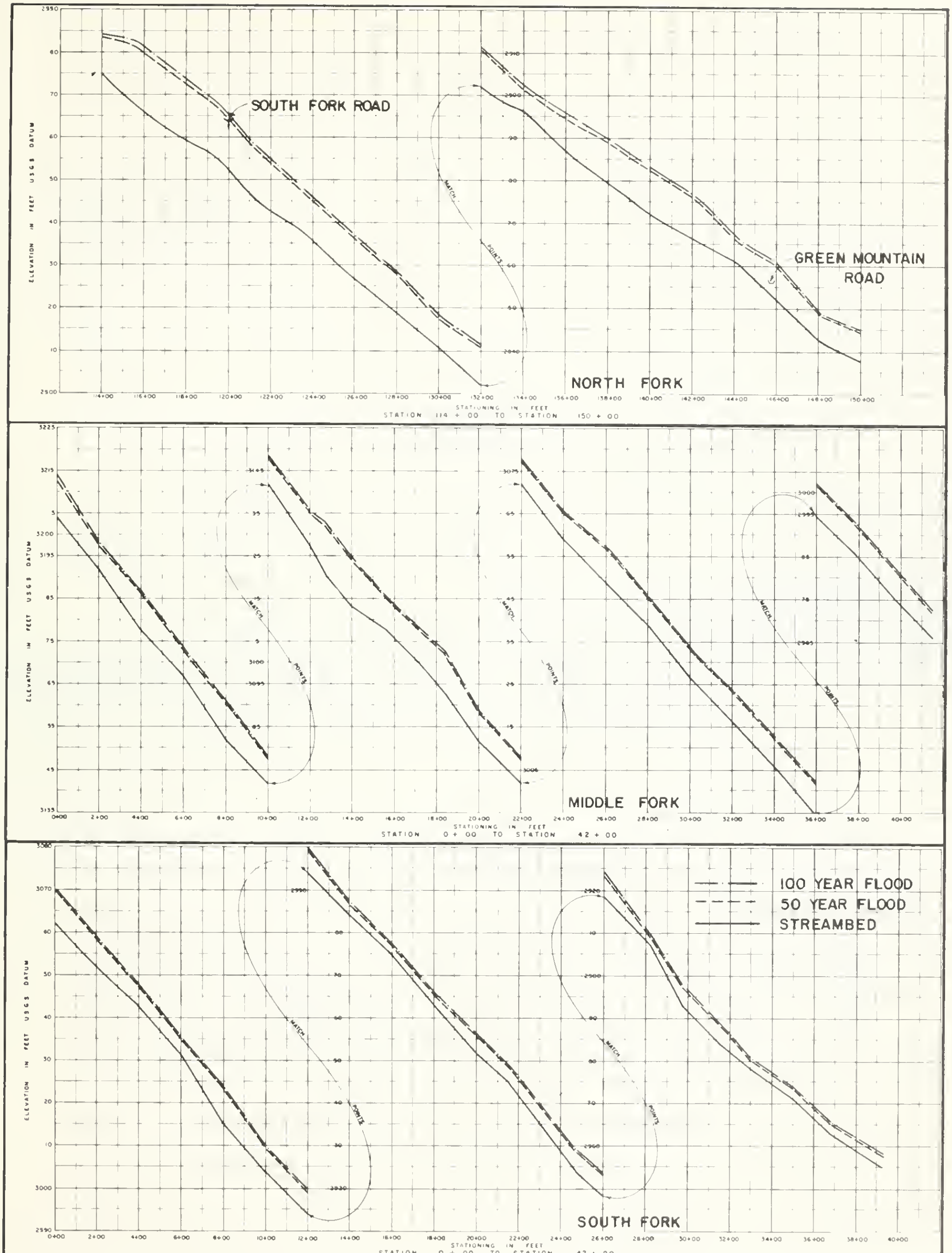


Figure 8 — FLOOD PROFILES: NORTH, MIDDLE AND SOUTH FORKS LYTLE CREEK

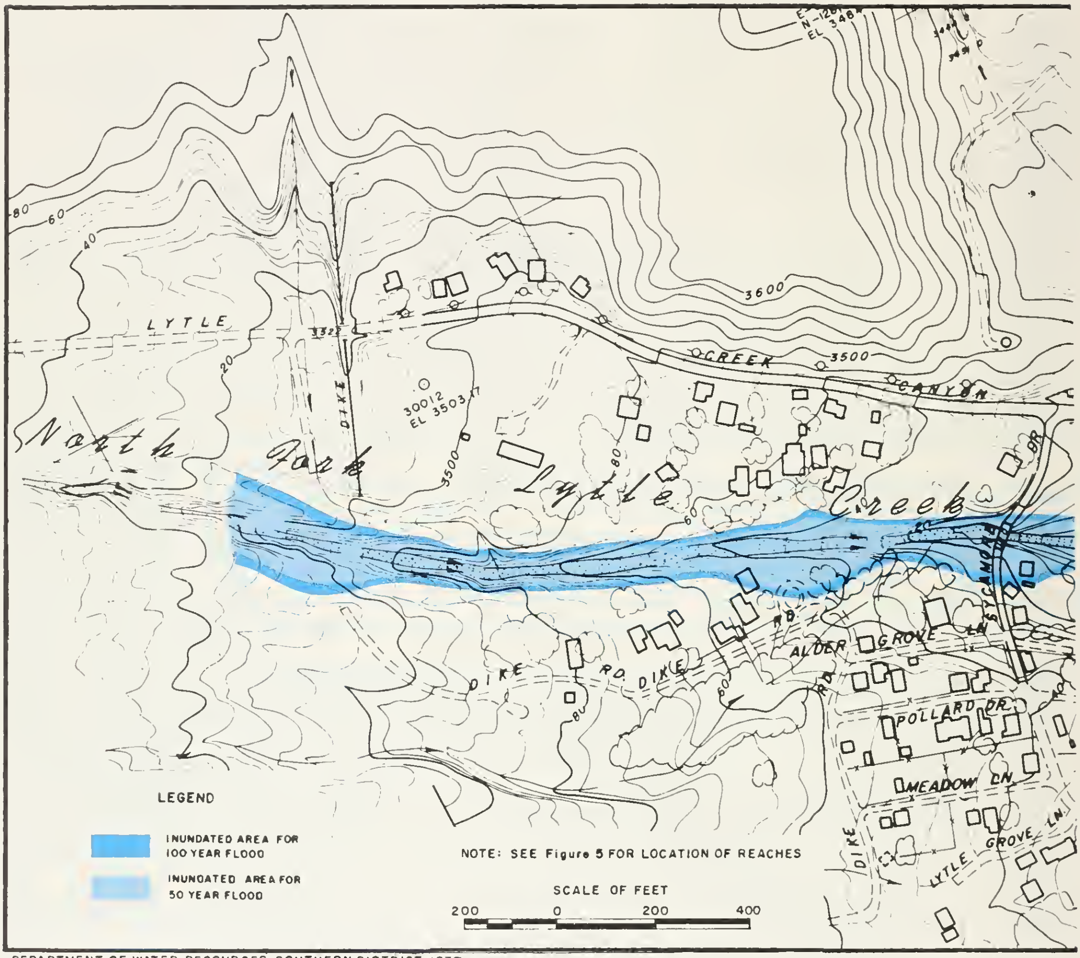


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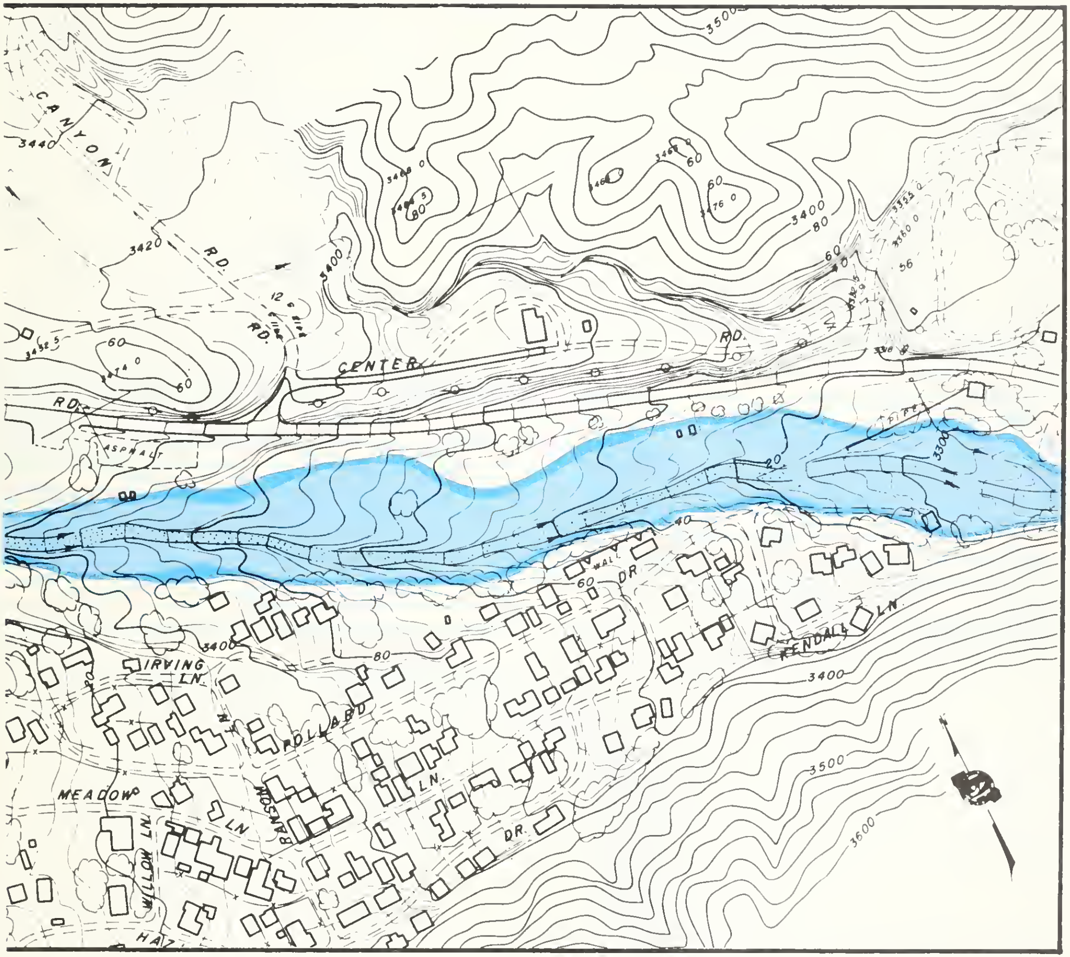
Figure 9 — AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH A

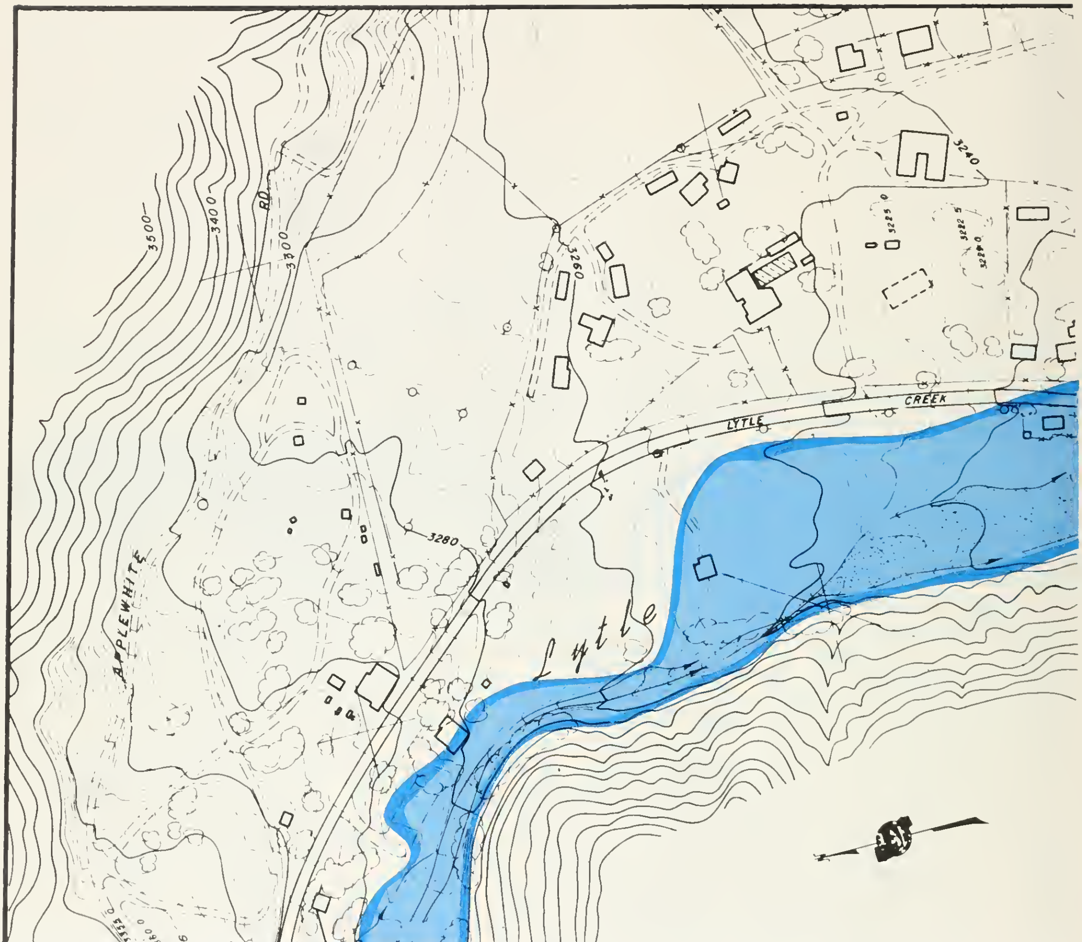


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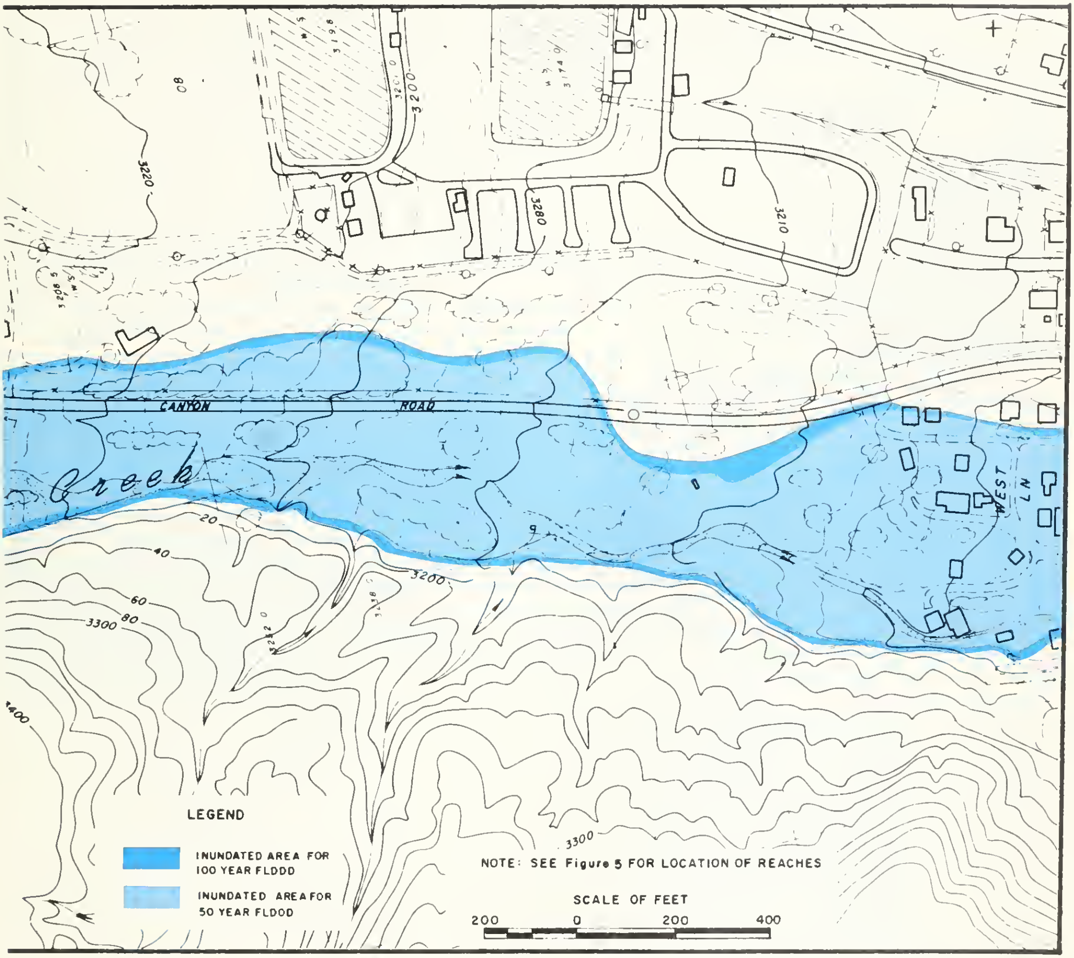
Figure 10 — AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH B

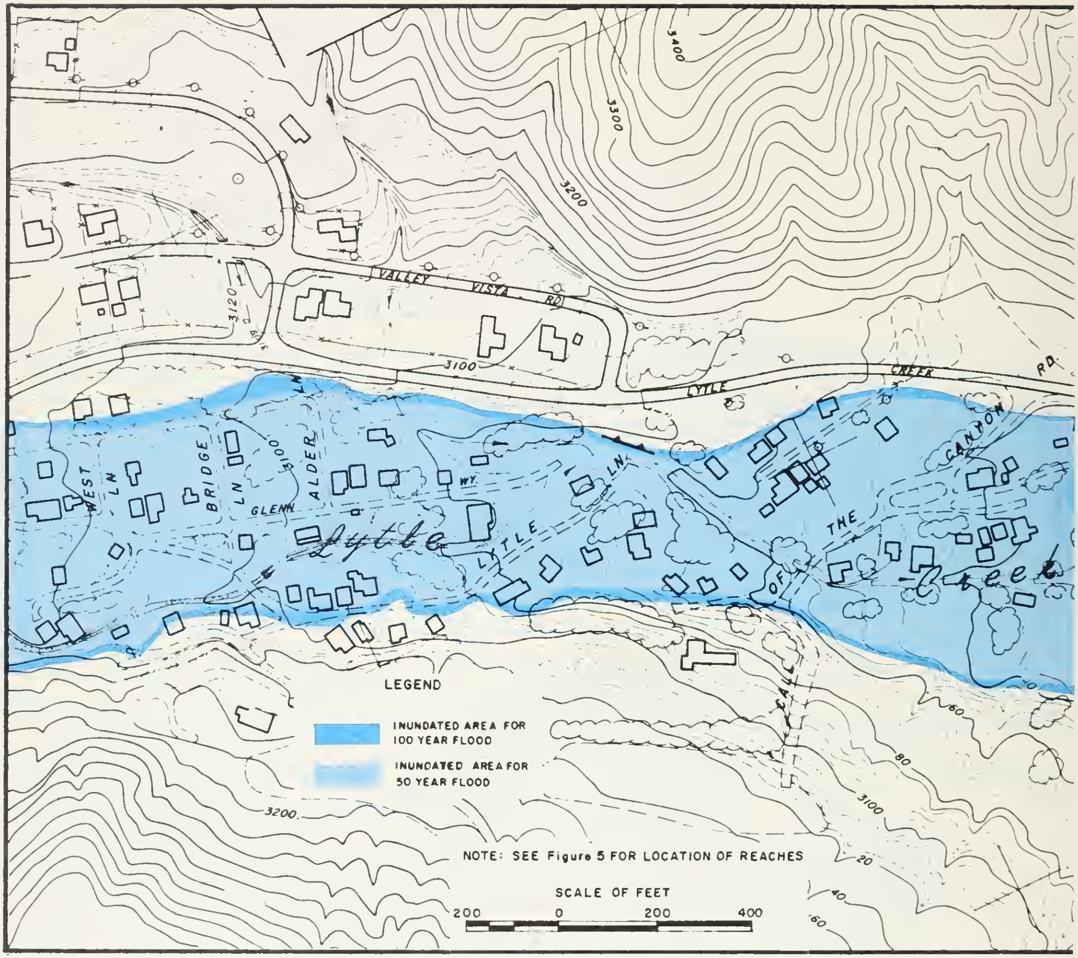


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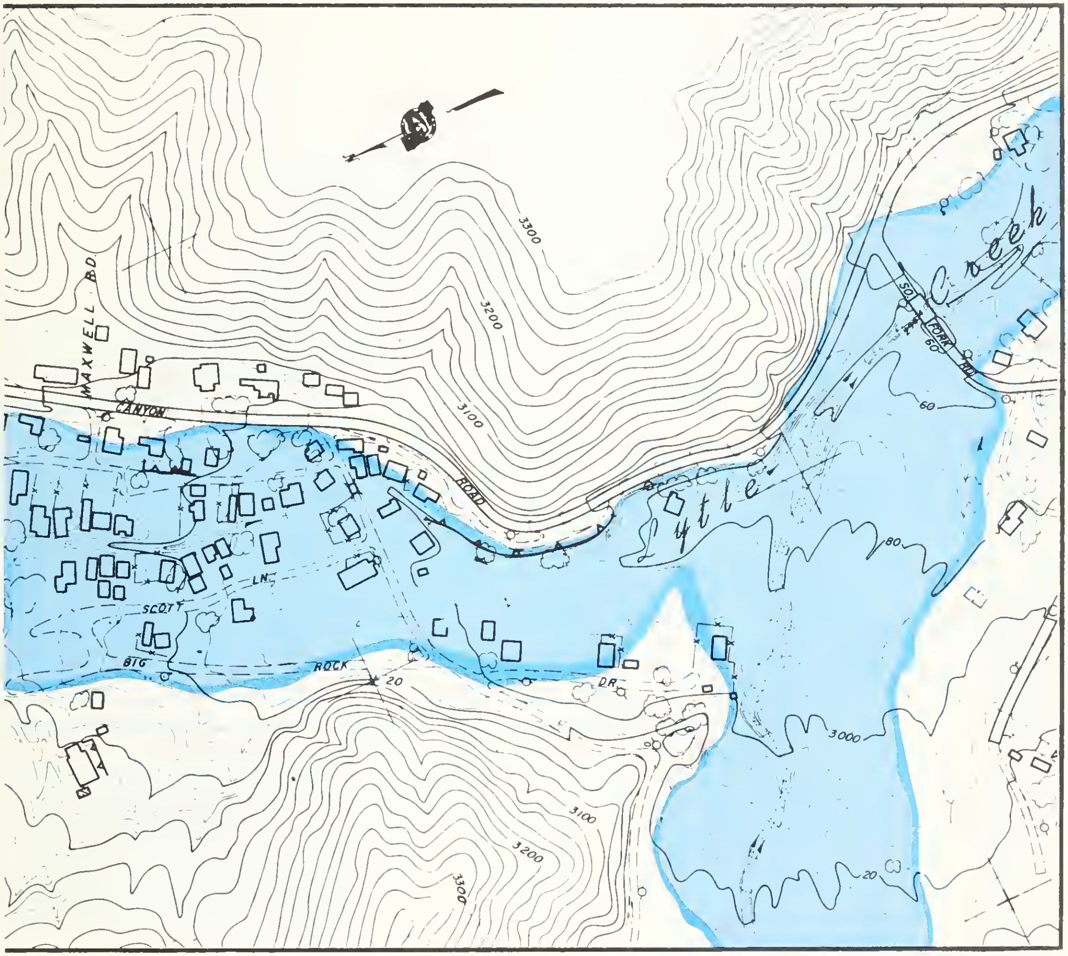
Figure 11 — AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH C

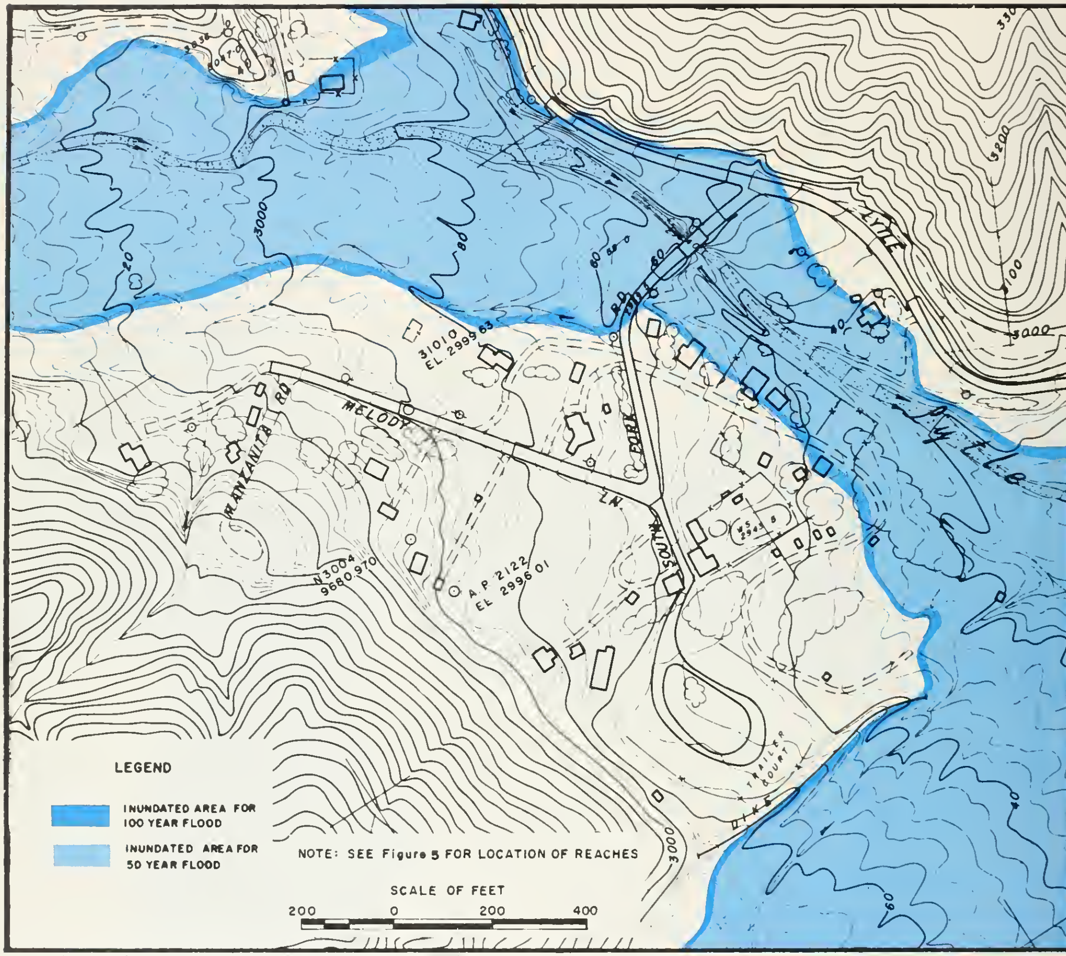


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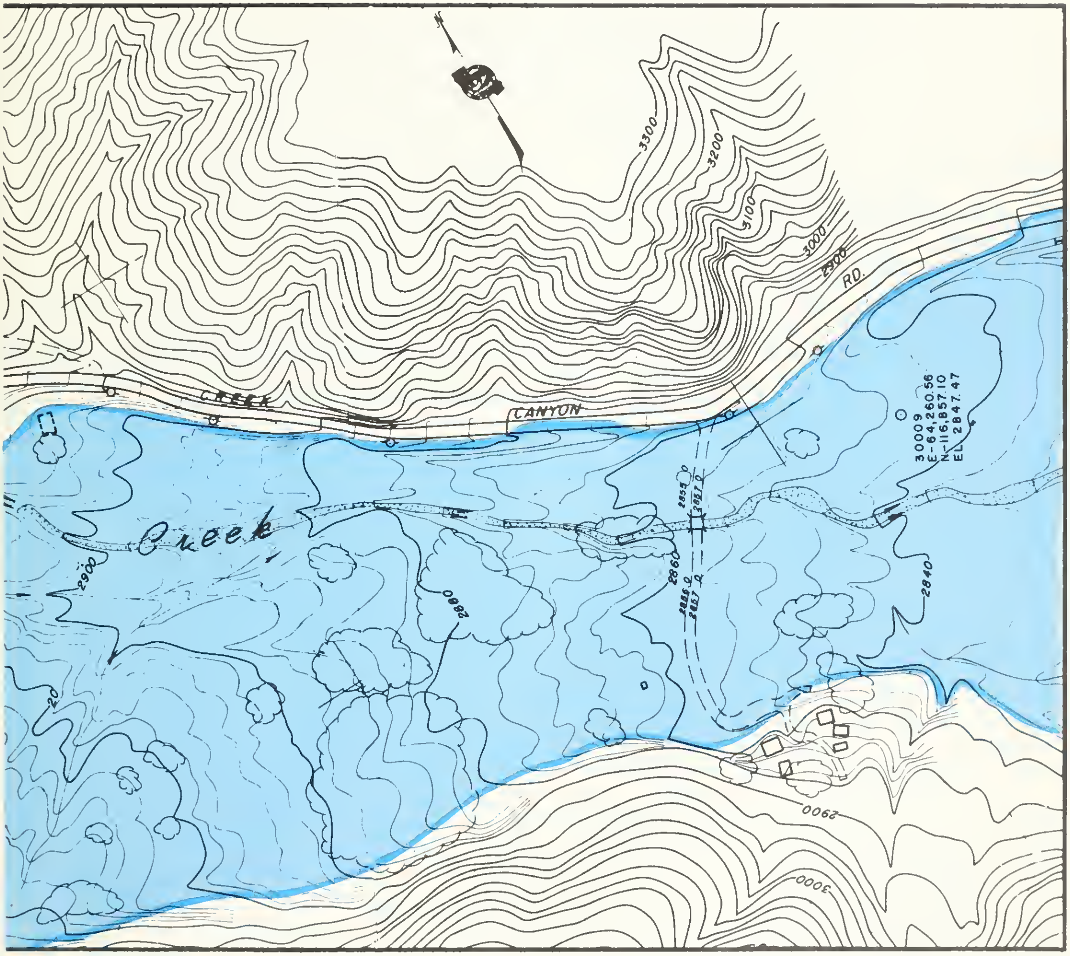
Figure 12 — AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH D

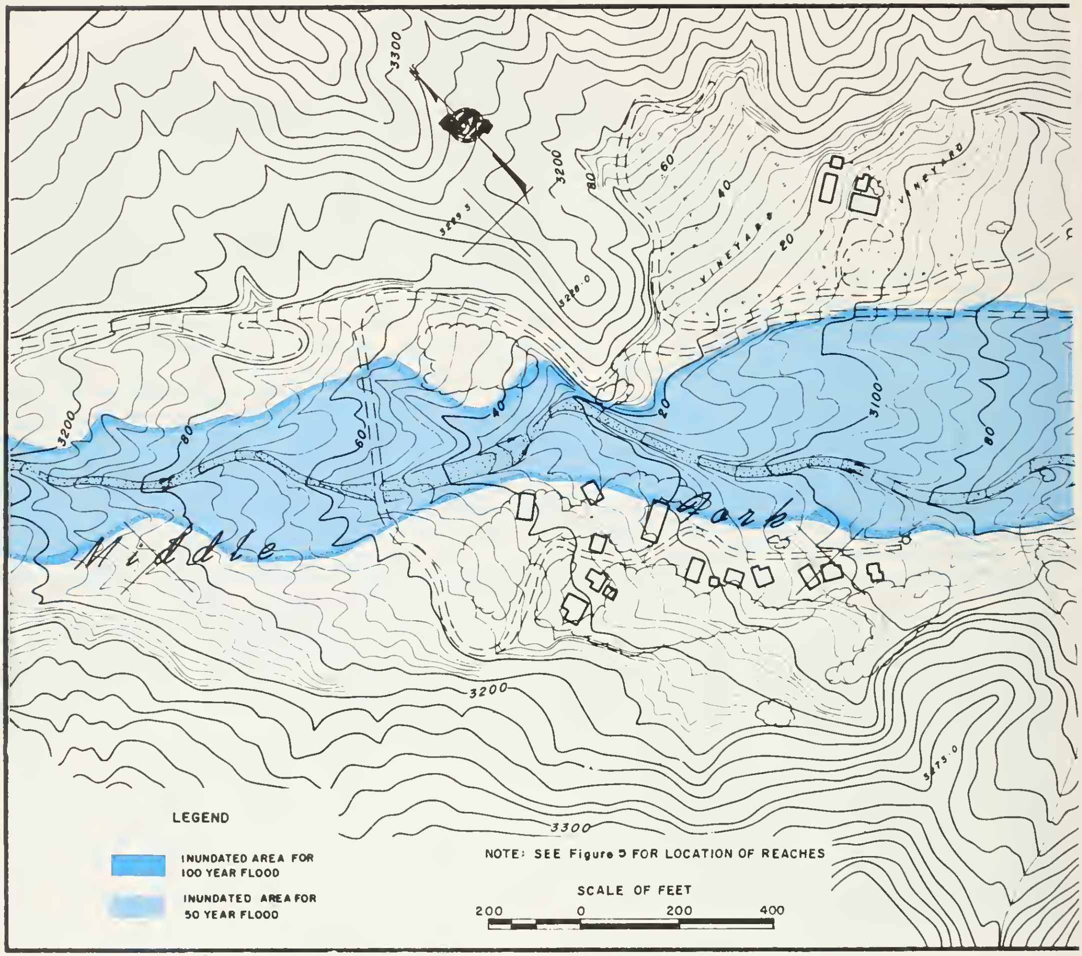


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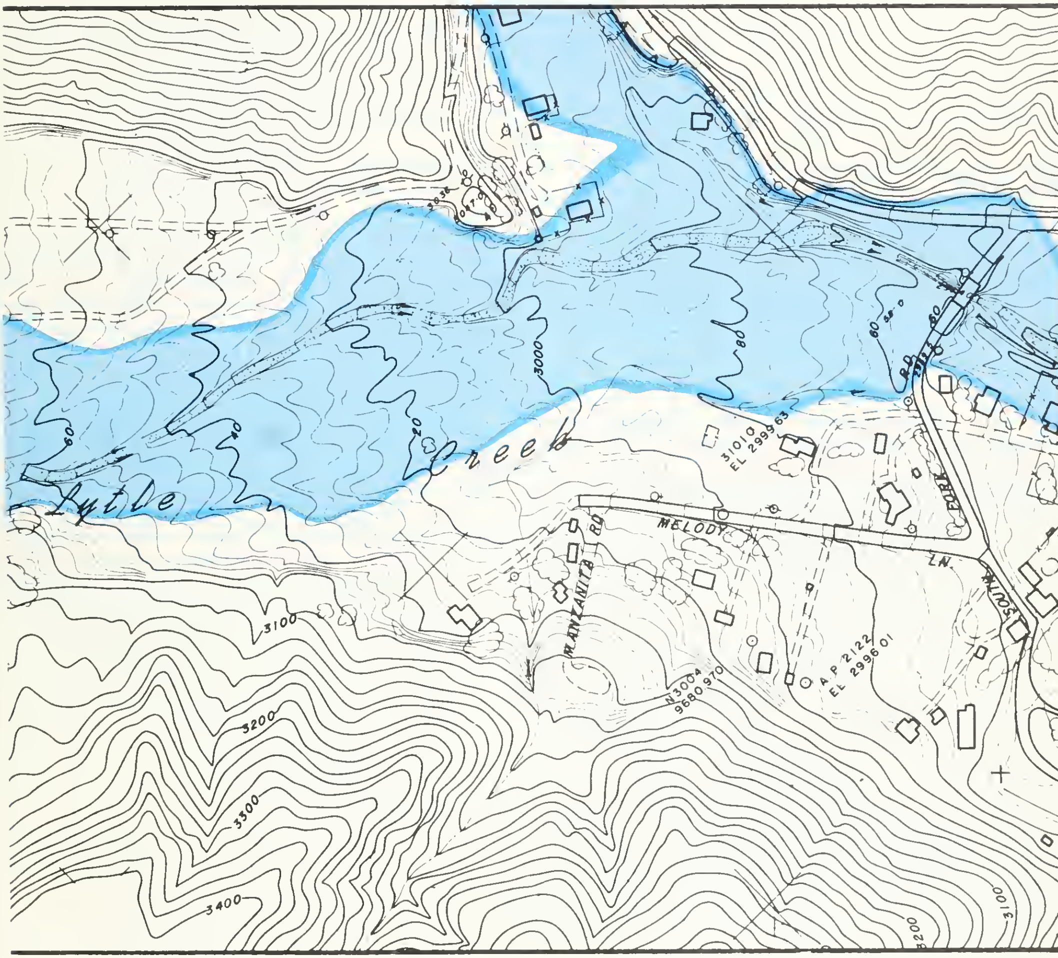
Figure 13 — AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH E

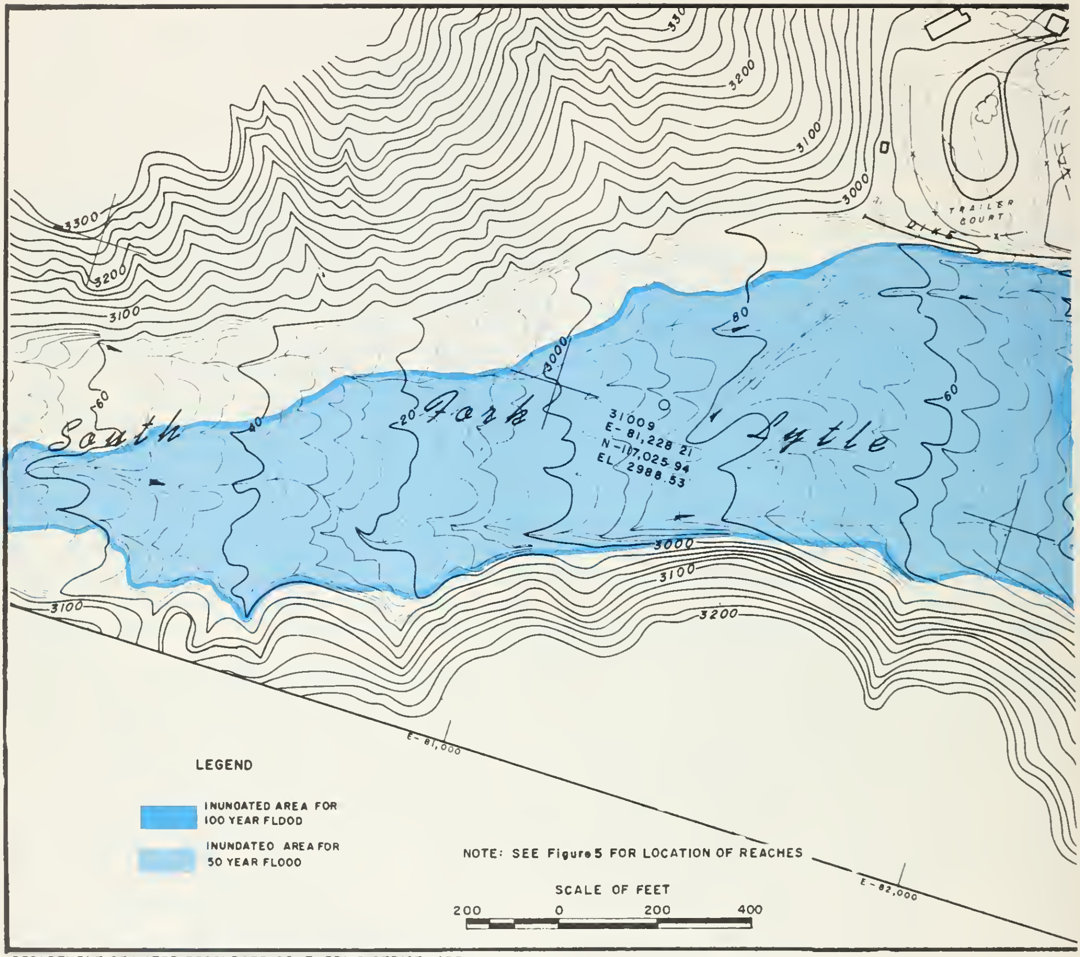


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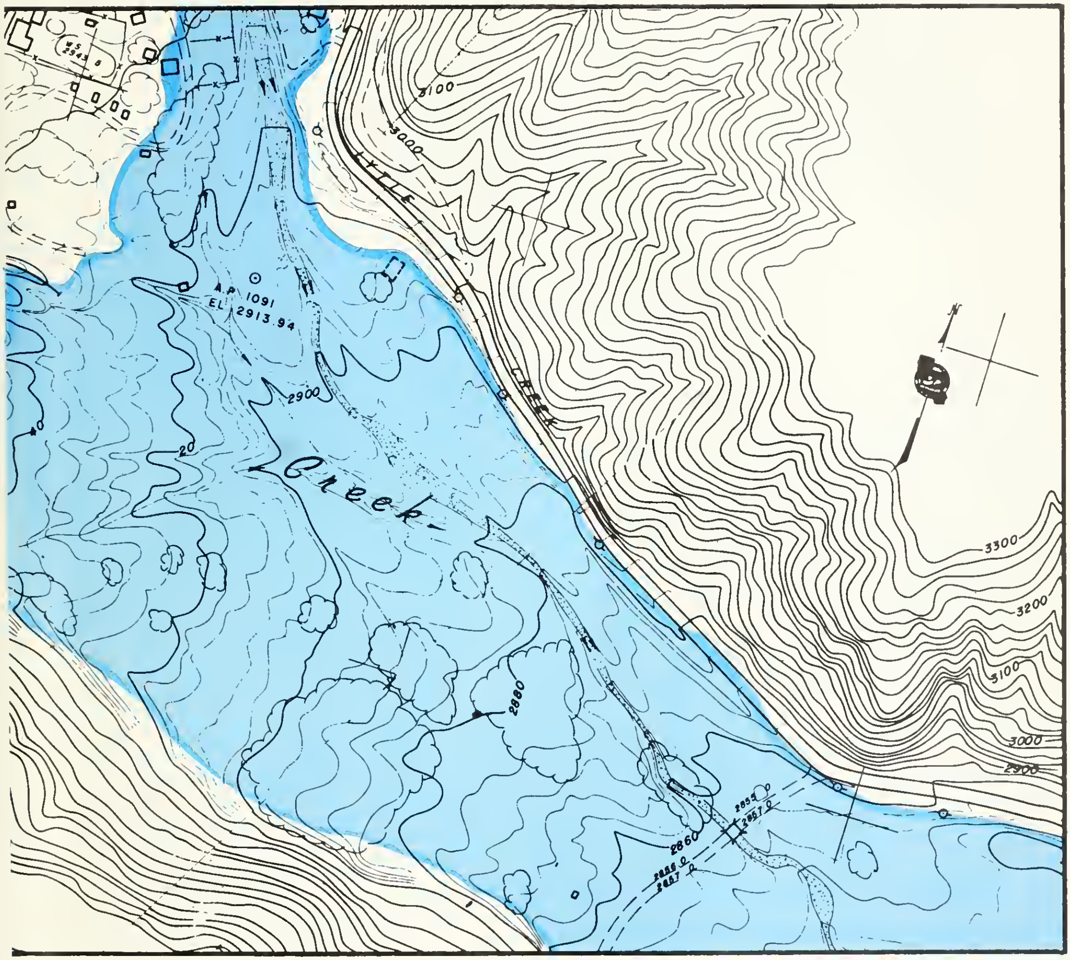
Figure 14— AREAS OF POTENTIAL INUNDATION:



LYTLE CREEK REACH F

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